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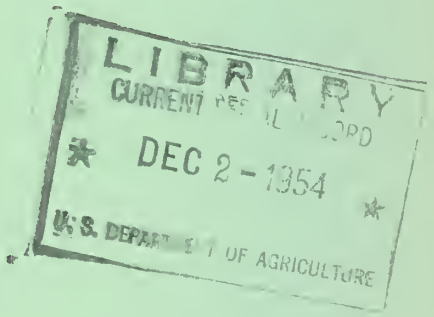
SEASONING CALIFORNIA HARDWOODS

H. H. SMITH



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SEASONING CALIFORNIA HARDWOODS

H. H. Smith

Utilization of the several hardwood timber species native to California has not kept pace with softwood lumber production. Difficulties encountered in seasoning hardwood lumber have largely accounted for its limited use. Some hardwood lumber has been successfully cut and remanufactured into flooring, but the results were not sufficiently encouraging to establish a going hardwood lumber industry. Results of several seasoning experiments, however, are now available[1/]. They indicate that past difficulties in the seasoning of western hardwood lumber can be overcome. This paper describes the drying procedure and results obtained in cooperative studies conducted at two mills in the redwood region of California--the Union Lumber Company at Fort Bragg and the Pacific Lumber Company at Scotia. Results of this work, though not productive of a final answer, add to the growing store of information that eventually may lead to more complete utilization of California's hardwood timber.

1/ Espenas, Leif D. 1953. The seasoning of one-inch tanoak lumber. Oregon Forest Products Laboratory Bul. 3. 46 pp. Corvallis, Oregon.

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Smith, Harvey H. 1949. Seasoning California black oak. California Forest and Range Experiment Station, Res. Note No. 62. 8 pp. Berkeley, Calif.

Smith, H. H. 1950. Further experiments in seasoning California black oak. California Forest and Range Experiment Station, Res. Note No. 75. 11 pp. Berkeley, Calif.

Torgeson, O. W. 1950. Kiln-drying schedules for 1-inch laurel, madrone, tanoak and chinquapin. Forest Products Laboratory No. R1684. 24 pp. Madison, Wisconsin.

Voorhees, Glenn. 1944. The essentials of kiln drying Oregon hardwood lumber. Oregon Forest Products Laboratory, Res. Leaflet No. 2. 17 pp. Corvallis, Oregon. (Mimeographed)

The California Forest and Range Experiment Station is maintained in cooperation with the University of California at Berkeley, California.

Agriculture--Berkeley

At Fort Bragg, tanoak (Lithocarpus densiflorus (Hook. & Arn.) Rehd), madrone (Arbutus menziesii Pursh), golden chinkapin (Castanopsis chrysophylla (Dougl.) A. DC.), and California-laurel (Umbellularia californica (Hook. & Arn.) Nutt.) were included in the test; at Scotia, tanoak and madrone.

The procedure used in seasoning these hardwoods was to first dry the lumber in unit packages on the air-drying yard, then move the lumber into kilns for drying to the desired final moisture content. This procedure is similar to the method of drying used extensively in Eastern hardwood-producing regions.

Experimental Drying of Hardwoods at Fort Bragg

At Fort Bragg thirteen logs were sawed into 1-inch and 1-1/2-inch lumber. Log sizes and volumes were as follows:

Species	Log diameter (inches)	Log length (feet)	Volume, Scribner rule (bd. ft. log scale)	
Tanoak	18	14	190	
	18	29	300	
	23	20	470	
Total tanoak volume:				960
Madrone	16	20	200	
	21	20	380	
Total madrone volume:				580
Golden chinkapin	14	14	100	
	14	16	110	
	16	20	200	
	18	20	270	
Total chinkapin volume:				680
California-laurel	18	16	210	
	19	14	210	
	20	20	350	
	21	20	380	
Total California-laurel volume:				1,150
Total volume, all species:				3,370

Air Drying

The lumber was segregated by thickness, but not by species, and piled in unit packages 4 feet by 4 feet by 16 to 20 feet for air drying. Two-inch Douglas-fir lumber was used for the bottom boards of each unit package. One-inch by 2-inch stickers were spaced 18 inches apart. Eighteen samples were prepared from representative material and placed in pockets within the units of lumber to follow the progress of the air drying.

In the redwood region along the coast, seasonal changes of temperature and humidity are small. Here there is no season favorable to fast drying. On this drying yard, the average monthly temperatures varied from 45.5°in January to 57° in September. The average monthly relative humidity in this area remains high throughout the whole year, varying only from a low of 77 percent in February to a high of 88 percent in August. The most important factors that influenced the rate of air drying were precipitation and the effectiveness of the pile-roofs or cover boards. The test piles were not covered to protect the lumber during rainy weather, and during rain storms considerable water entered the piles, causing the lumber to regain moisture.

The four hardwoods dried differently on the air-drying yard (fig. 1). California-laurel dried to the lowest moisture content and showed the least amount of drying degrade. Much of the laurel came from one large, very gnarled, irregularly shaped log. The lumber was beautifully figured due to the irregular grain. Even this highly figured, cross-grained lumber remained surprisingly flat during air drying. Surface checking was not serious, though some checking developed, particularly in the extremely cross-grained pieces.

Tanoak showed a tendency to surface check during air drying, but remained relatively flat. The greatest amount of checking, and some excessive shrinkage that could almost be classed as collapse, developed in dark areas of the heartwood. These dark areas appeared to be similar to the mineral streak of hard maple lumber. The amount of dark heartwood varied considerably from log to log and in lumber from the same log. An estimated 10 percent of the tanoak lumber contained this type of defect.

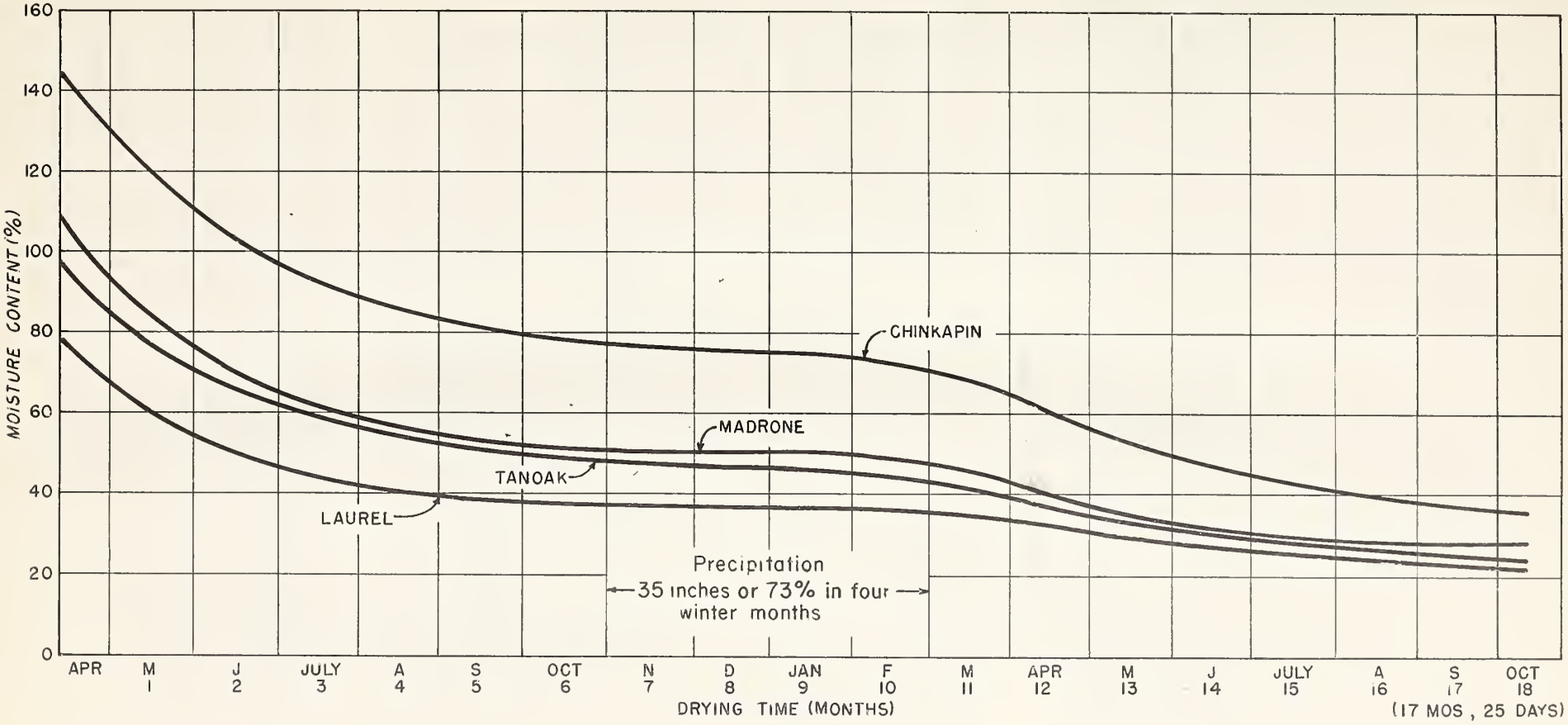

FIGURE 1
AIR DRYING OF CALIFORNIA HARDWOODS AT FORT BRAGG
(1-1/2 - INCHES THICK)

The madrone lumber showed less tendency to check than did the tanoak, but warped excessively. The principal warp was in the form of cupping toward the bark side of flat-sawed pieces. The shrinkage values for madrone as listed in the U. S. D. A. Technical Bulletin 479, "Strength and Related Properties of Woods Grown in the United States," are 11.9 percent in the tangential direction, but only 5.4 percent in the radial direction. The figure for volumetric shrinkage is 17.4 percent. Few other hardwoods have so high a ratio of tangential to radial shrinkage or so high a volumetric shrinkage. Thus madrone, because of its inherent shrinkage characteristics, can be classed as a wood that is prone to warp during seasoning.

Golden chinkapin showed the greatest tendency to develop checking and collapse of the four woods dried. Collapse developed during drying on the air yard under very mild drying conditions. The chinkapin also required longer to air dry to a moisture content suitable for final kiln drying.

Kiln Drying

The kiln drying of thoroughly air-dried hardwoods is usually relatively easy. Checking and honeycombing of the wood are associated with the loss of free water. Hence, air-dried hardwood lumber at an average moisture content of 20 percent or less can be kiln dried with little danger of new checks or honeycomb developing. Shrinking, however, will continue during kiln drying, and warping will become more pronounced.

Two kiln runs of one-inch hardwoods were made, the first using a relatively mild schedule for air-dried lumber and the second using a more severe schedule (figs. 2 and 3).

California-laurel was the only species of the four that dried with little or no difficulty. Cupping of flat-sawed lumber, owing to the high ratio of tangential to radial shrinkage, was the most objectionable dry defect encountered with the other three woods. This type of defect was serious in madrone and developed to a lesser degree in tanoak and chinkapin. In the chinkapin, excessive shrinkage or collapse also was serious. Old checks that opened during the early stages of kiln drying soon reclosed and remained closed as the moisture gradient flattened out.

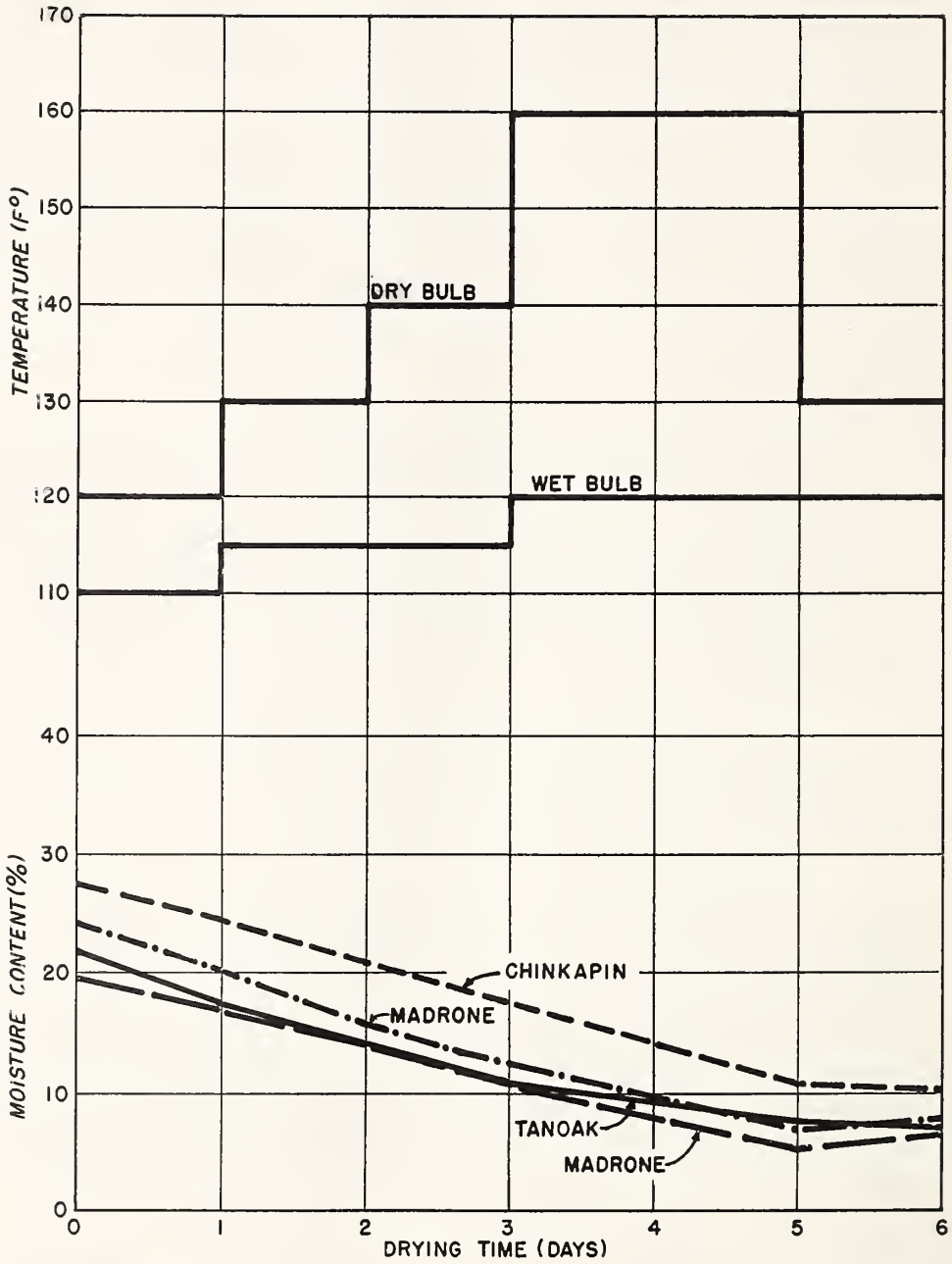

FIGURE 2
KILN RUN No. 1, FORT BRAGG, CALIFORNIA
1-INCH CALIFORNIA HARDWOODS

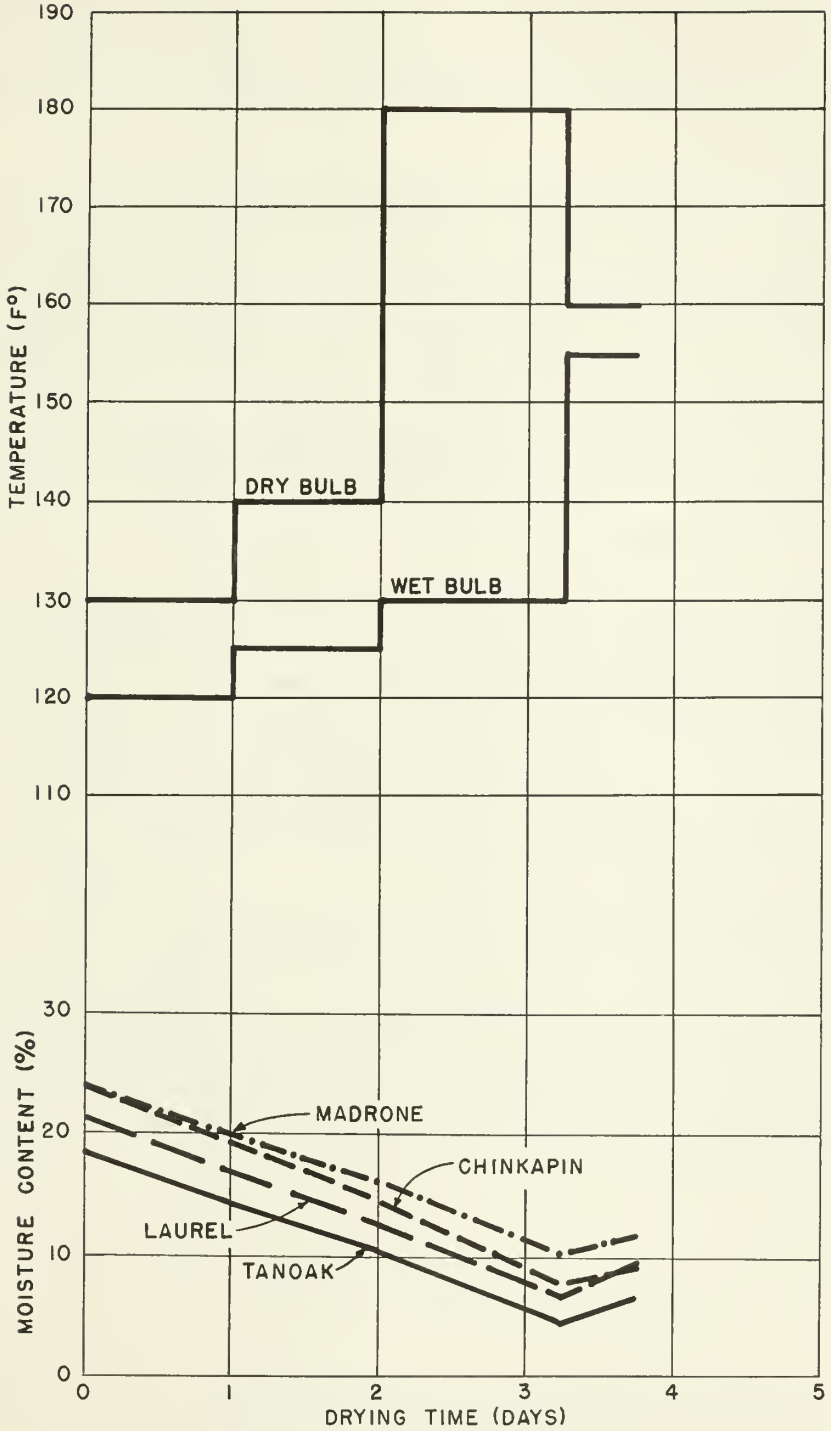

FIGURE 3
KILN RUN No. 2, FORT BRAGG, CALIFORNIA
1-INCH CALIFORNIA HARDWOODS

The stresses that developed during the kiln drying were only partially relieved by the mild stress relief used after run No. 1. This lumber was later reconditioned during the final conditioning of run No. 2. Samples from kiln run No. 2 increased in moisture content an average of 2.1 percent during 12 hours of conditioning at 160-155° F. Good relief of drying stresses in lumber of both kiln runs was accomplished.

Kiln drying the 1-1/2-inch hardwood was delayed to permit 2 additional months of air drying. By the middle of October (18 months, including 2 summers) the laurel had dried to a moisture content of 22 percent, tanoak 24 percent, madrone 28 percent, and chinkapin 35 percent. Continued air drying after this date would be of doubtful value; therefore, the lumber was kiln dried even though the moisture content was not as low as desired. The kiln drying time for the 1-1/2-inch lumber was 192 hours or 8 days (fig. 4); more than twice the time required for drying the 1-inch lumber in kiln run No. 2. The severity of the drying schedule used was similar to run No. 2.

The results obtained in drying the 1-1/2-inch hardwood were less favorable than those obtained in drying the 1-inch lumber. Checking was most serious in the flat-sawed boards of tanoak and chinkapin. Flat-sawed boards with a sharp curvature of the growth rings also cupped severely. Other forms of warping, such as twisting and bowing, indicated the need for careful piling for drying. Collapse was most serious in chinkapin, though some did occur in the madrone, usually adjacent to knots and similar defects.

Experimental Drying of Hardwoods at Scotia

At Scotia 6 logs of tanoak and madrone were sawed into 3/4-inch and 1-1/4-inch lumber. Three logs of Hinds walnut (*Juglans hindsii* Jeps.), not included in the original plan were sawed into 1- and 2-inch lumber and dried along with the other hardwoods. Log sizes and volumes were as follows:

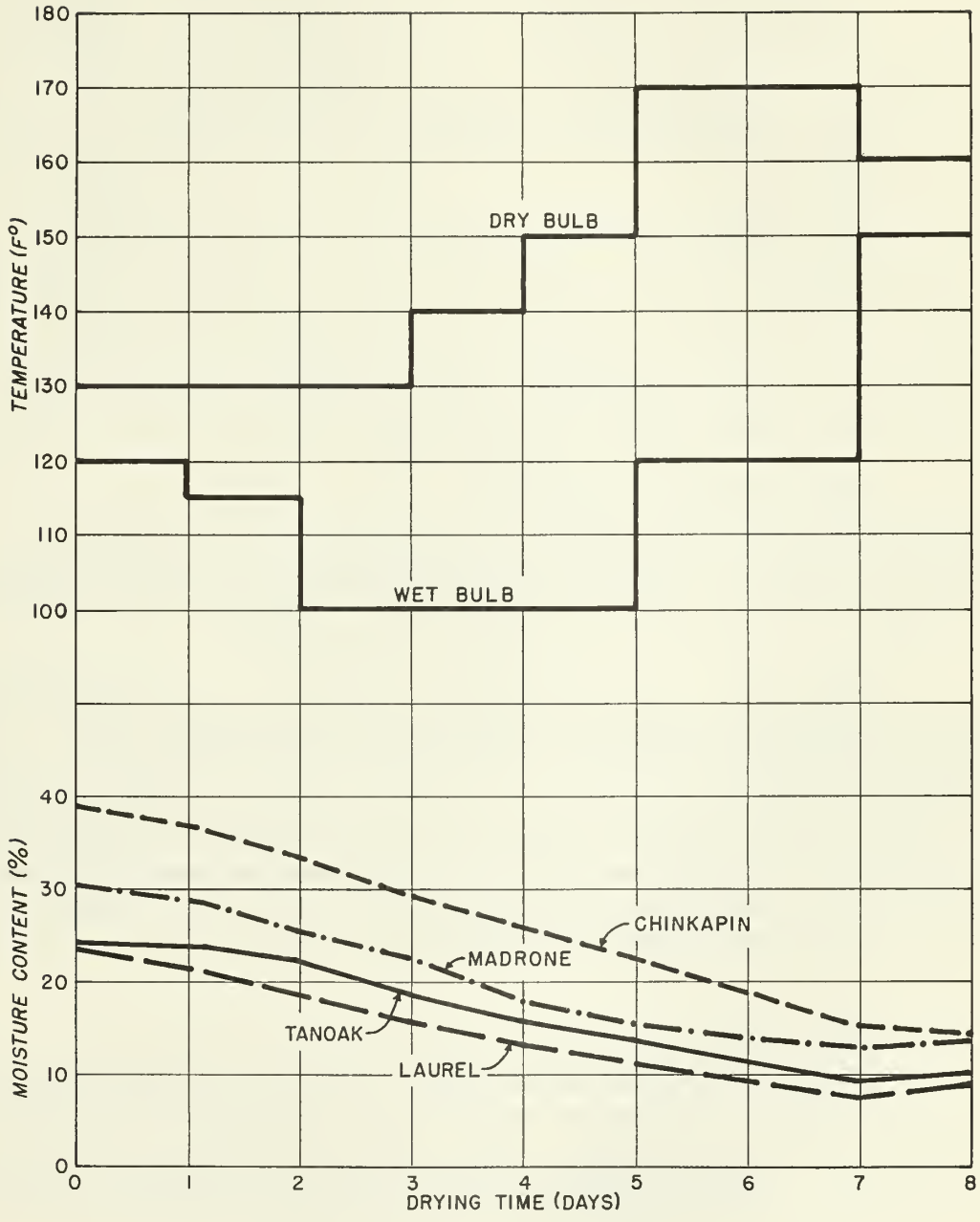

FIGURE 4
KILN RUN No. 3, FORT BRAGG, CALIFORNIA
1-1/2-INCH CALIFORNIA HARDWOODS

Species	Log diameter (inches)	Log length (feet)	Volume, Scribner rule (bd.ft. log scale)	
Tanoak	13	18	110	
	16	20	230	
	22	25	540	
	25	20	570	
	29	27	1,060	
Total tanoak volume:				2,510
Madrone	32	26	1,200	
Total madrone volume:				1,200
Walnut	21	12	120	
	33	12	590	
	48	10	1,080	
Total walnut volume:				1,790
Total volume, all species:				5,500

The Hinds walnut dried easily without defects. Since the walnut presented no special problems and was not included in the original plan, no further reference will be made to this species.

The lumber was segregated by thickness and species and piled in unit packages 4 feet by 4 feet by 16 feet and 20 feet. Two-inch Douglas-fir bottom boards were again used in the first course as a foundation for each package. There was sufficient tanoak to make one package of 3/4-inch and one of 1-1/4-inch lumber. Similar packages of madrone were filled out with some tanoak and some Hinds walnut lumber. Two other packages were made up, one of 2-inch walnut and one of walnut and tanoak of all sizes.

Air Drying

Twenty-one samples were prepared from representative material and placed in pockets within the packages of lumber for determining the moisture loss on the yard. The packages were piled on the yard for air drying. The test lumber was piled three units high, with three units of redwood on top, making piles six units high.

The hardwood lumber dried rapidly on the yard, particularly after March, when the rainy winter weather ended (fig. 5). The unit packages were repiled during the air drying, thus changing the drying rates of different samples. Also, some samples were not accessible during part of the air-drying period. Consequently the average moisture content indicated for each thickness of each species is not always an average for identical samples. However, the figures do indicate that 1-inch lumber of both tanoak and madrone can be air dried to a moisture content suitable for final kiln drying in less than one year in this area when piled during the winter or early spring so as to take full advantage of the summer months when there is little or no rain.

The amount of defects that developed in the tanoak and madrone during air drying was relatively small. This is somewhat in contrast to the results obtained at Fort Bragg where the tanoak showed a tendency to check and the madrone to warp. The more favorable drying results at Scotia were apparently due to three factors: (1) thinner, narrower lumber, (2) a very high percentage of quarter-sawed lumber, and (3) uniform thickness of lumber that permitted better piling.

These results indicate that perhaps faster drying by opening the yard (wider spacing of the piles) can be tried with little or no increase in the amount of drying defects.

Kiln Drying

Half of the 1-1/4-inch tanoak and madrone was dried along with vertical grain Douglas-fir flooring strips in a commercial kiln (Table 1). Both hardwoods dried from a moisture content slightly higher than 20 percent to a final moisture content of 6 percent in 6-1/2 days. The final conditioning for 3 hours at 170° F. dry bulb and 164° F. wet bulb temperature did not completely relieve the drying stresses. Actually, the 6° F. depression was not reached until the end of the conditioning period.

The remainder of the 1-1/4-inch tanoak and madrone was dried along with 1-1/4-inch redwood in a commercial kiln (Table 2). The hardwood dried from a moisture content slightly higher than 20 percent to a moisture content of 4.4 percent in 9 days. After two days of equalizing and one day of conditioning the moisture content was increased to 6.5 and drying stresses were completely relieved.

The commercial operator who dried these two units of tanoak and madrone felt the second, longer and milder schedule was the better. No hardwood lumber grader was available for determining the grade before and after kiln drying. The results of the two runs were judged by comparing the quality of the lumber as it was repiled into solid units.

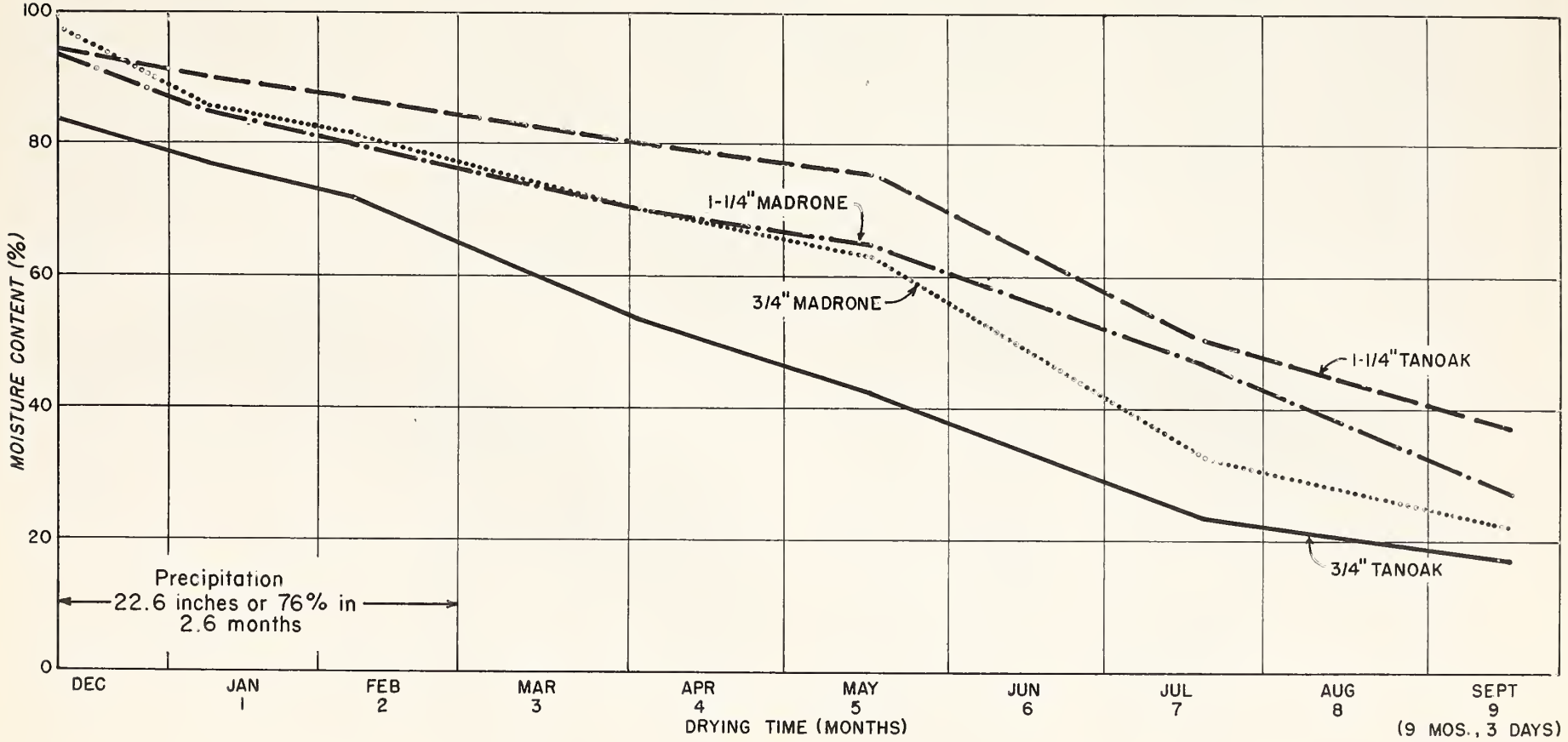

FIGURE 5
AIR DRYING OF CALIFORNIA HARDWOODS AT SCOTIA

Table 1. --Commercial kiln schedule for 1-inch vertical grain Douglas-fir flooring strips

Time, days	Temperature		Equilibrium moisture content
	Dry bulb	Wet bulb	
	(° F.)	(° F.)	(percent)
1	130	120	12.1
1	135	120	9.7
1	140	125	9.6
1/2	150	130	8.0
1/2	160	135	6.8
1/2	160	130	5.8
1/2	165	130	5.0
1-1/2	170	120	3.2
Condition (for 3 hrs.)	170	164	14.0

Table 2. --Commercial kiln schedule for 1-1/4-inch redwood lumber

Time, days	Temperature		Equilibrium moisture content
	Dry bulb	Wet bulb	
	(° F.)	(° F.)	(percent)
Drying:			
3	110	90	7.7
1	120	94	6.3
1	120	92	5.8
1	130	99	5.4
1	140	106	5.0
1	150	113	4.6
1	160	120	4.3
Equalizing:			
1	160	140	7.9
1	160	150	11.5
Conditioning:			
1	165	160	15.0

Experimental kiln drying of lumber in a commercial kiln along with a large charge of other wood has definite limitations. The drying temperatures and humidities and the length of the drying period all must be acceptable for the large charge of lumber being dried. Seldom are these drying conditions optimum for the test material.

About the time the 1-1/4-inch lumber was dried, plans were completed for building a small one-unit capacity, experimental kiln at this plant. The drying of the 3/4-inch lumber was therefore delayed until the experimental kiln was available. There would then be no limitations on the drying conditions used and schedules considered most suitable for drying the 3/4-inch tanoak and madrone could be used. During this delay of approximately three months, the air-dried lumber was again moved on the yard and piled unprotected from the winter rains. A moisture pick-up of more than 35 percent occurred.

The two kiln runs then were made in the small experimental kiln (figs. 6 and 7). In run No. 4 an estimated 25 percent of the tanoak was clear. In this clear wood no drying defects developed. In run No. 5 more than 75 percent of the madrone was clear, and no drying defects developed. Most of the degrade in tanoak resulted from the greater number of knots and the dark-colored heartwood (mineral streak).

The successful air drying and kiln drying of the tanoak and madrone at Scotia was apparently the result of better piling and the thinner sizes. This test material was more accurately sawed to a uniform thickness and could be piled on stickers for drying so that the lumber was held flat. A high percentage of the lumber was quarter-sawed, and did not cup as did the flat-sawed material; thus the finished kiln-dried product was of good quality.

Conclusion

The results obtained in the air drying and kiln drying of tanoak, madrone, California-laurel, and chinkapin make us hopeful of developing suitable drying procedures for the first three of these four species. The results lead to the following conclusions:

(1) One and two-inch laurel is relatively easy to dry, and seasoning need not limit utilization of this species.

(2) One-inch lumber of tanoak and madrone can be seasoned by a combination of careful air drying followed by kiln drying to the desired final moisture content. Tanoak and madrone lumber in thicknesses greater than one-inch will be difficult to dry satisfactorily even under carefully controlled conditions.

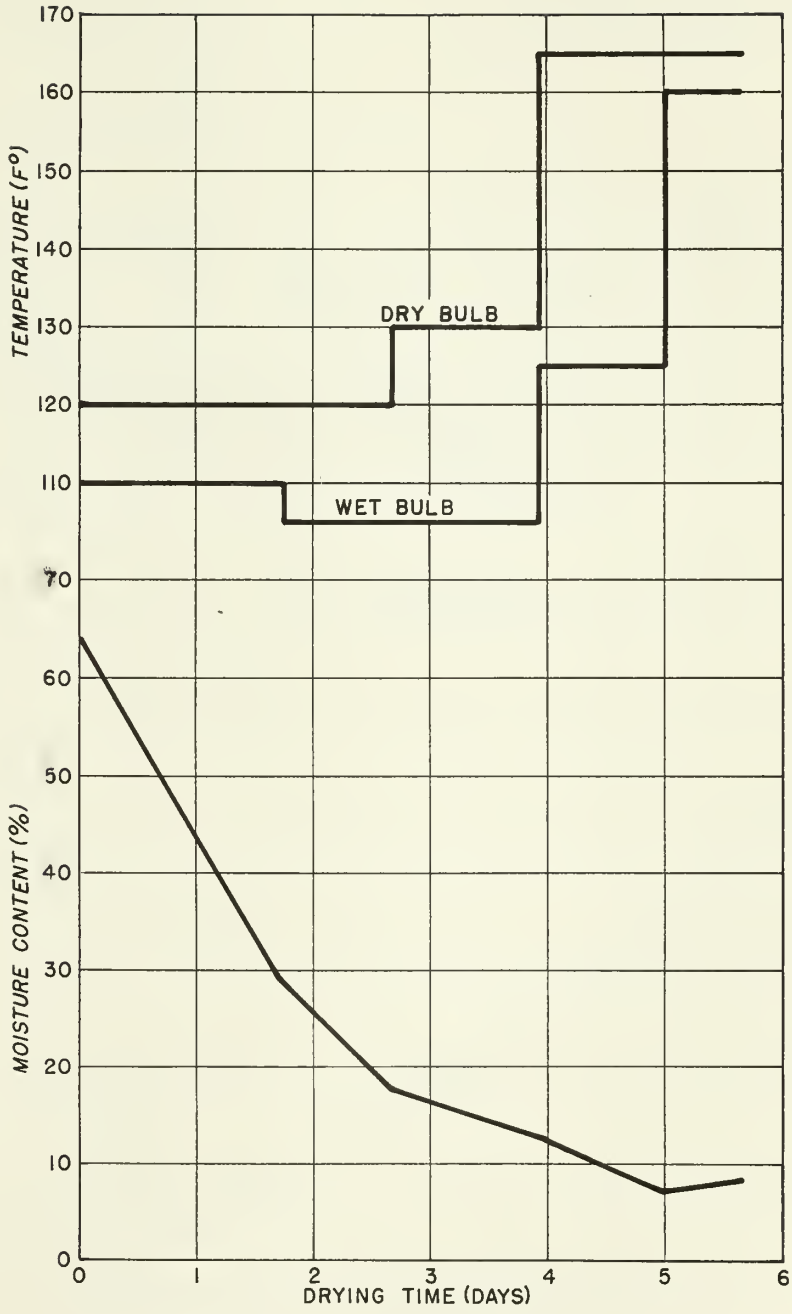

FIGURE 6
KILN RUN No. 4, SCOTIA, CALIFORNIA
3/4-INCH TANOAK
(RAIN-WET, WAS PREVIOUSLY THOROUGHLY AIR-DRIED)

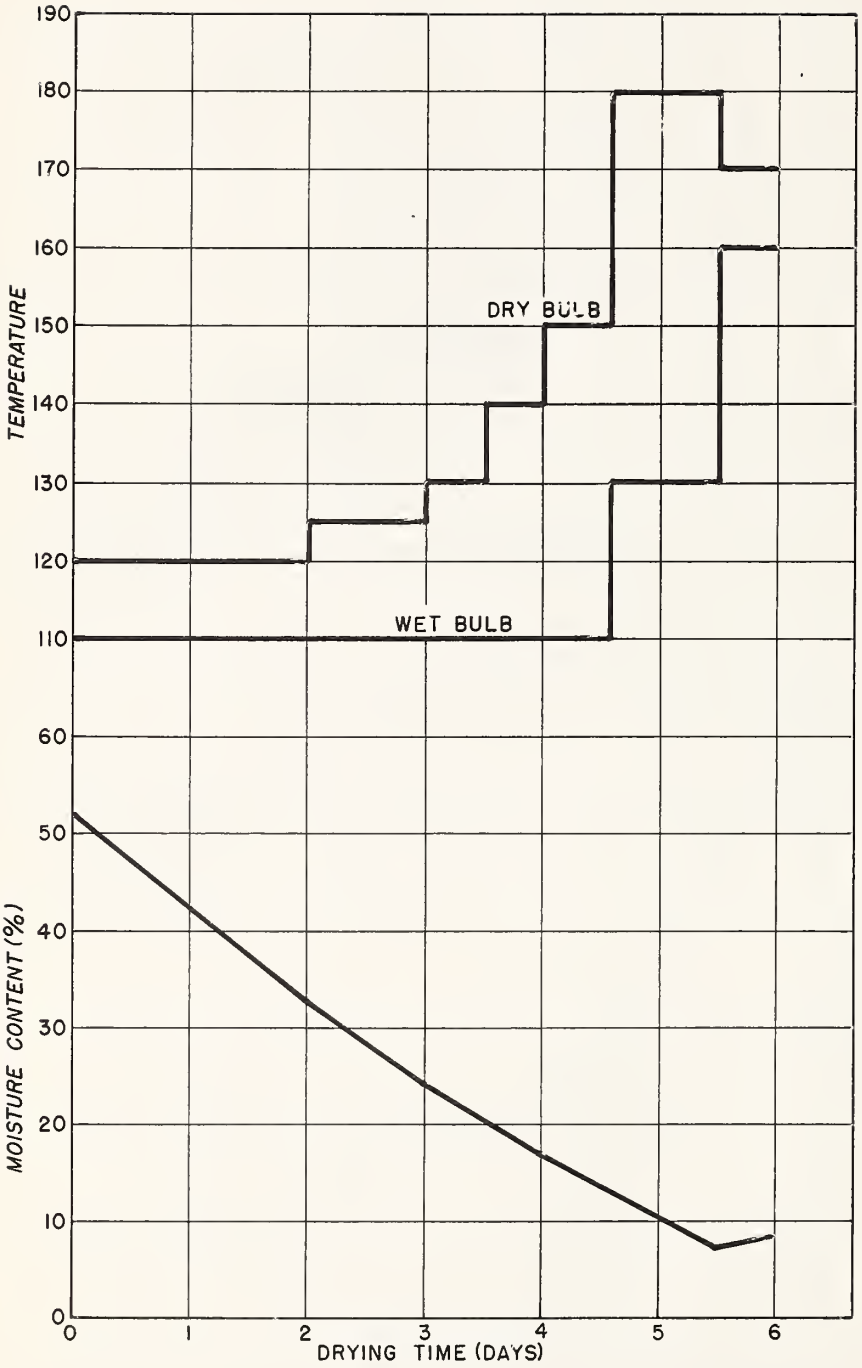

FIGURE 7
KILN RUN No 5, SCOTIA, CALIFORNIA
3/4-INCH MADRONE
(RAIN-WET, WAS PREVIOUSLY THOROUGHLY AIR-DRIED)

(3) This experiment indicates chinkapin lumber is the most difficult to dry of the four hardwoods dried. Excessive degrade developed during the drying of this species.

(4) Warping was the most serious difficulty encountered in the seasoning of these woods. Measures to minimize warping during drying, such as good piling practices, are therefore important. Accurate sawing of the lumber is essential to facilitate good piling.

Suggested Schedule for Kiln Drying

The U. S. Forest Products Laboratory at Madison, Wisconsin, has suggested schedules for all four species of California hardwoods included in the experiment[2/]. This California study indicates that somewhat milder drying conditions than those suggested by the Forest Products Laboratory might be advisable. Such schedules are listed below for air-dried one-inch tanoak, madrone, and California laurel. The results of the experimental drying of chinkapin were not satisfactory, and further work will be required before a schedule can be suggested for this species.

2/ Torgeson, O. W. 1951. Schedules for the kiln drying of wood. Forest Products Laboratory No. D1791. 15 pp. Madison, Wisconsin.

Suggested kiln schedule for thoroughly air-dried, 1-inch tanoak and madrone

Moisture content from (percent)	to (percent)	Dry bulb temp. (° F.)	Wet bulb temp. (° F.)
Above	25	120	110
25	20	130	115
20	15	140	115
15	Final	180	130

Suggested kiln schedule for thoroughly air-dried, 1-inch California-laurel

Moisture content from (percent)	to (percent)	Dry bulb temp. (° F.)	Wet bulb temp. (° F.)
Above	25	130	120
25	21	140	125
20	15	150	125
15	Final	180	130

For relieving the drying stresses, a final equilibrium moisture content of at least 4 percent above the moisture content of the kiln-dried lumber should be maintained for 8 to 12 hours, or until the lumber has increased in moisture content approximately 2 percent.